Low Cost Automatic Transmission Line Sectionalizing

The Ohio State University
Distinction Project
Autumn 2009
Andrew Dulmage

EXECUTIVE SUMMARY

This report contains detailed information about the design, testing and completion of an automatic transmission line sectionalizing approach. Below is an outline of what will be discussed in each section.

Introduction

The purpose of this project is to design an automatic transmission line sectionalizing system that is not only cheap, but reliable and flexible. The design will utilize the SEL-2411 Programmable Automation Controller (PAC), along with two motor operated air brake switches (MOABs).

Background & Market Research

Currently, there are many line sectionalizing schemes in existence. However, most of these schemes require multiple controllers which increases cost. This section will discuss this in further detail.

Requirements Analysis

This section will discuss the overall project analysis and implementation considerations.

Design Approach

Details about all of the components used in the design are presented first followed by the system design itself. This section also contains information about problems encountered during the design process and accommodations that were made to deal with these problems.

The overall system can be broken down into three main components, the SEL-2411 PAC, two MOABs, and two potential transformers. Most of this report will deal with the programming of the SEL-2411 PAC. However, it is important to discuss the potential transformers and MOABs being used to interface all these devices correctly.

Resources/Misc

This section discusses the available resources and also gives some background information about Andrew Dulmage.

1. INTRODUCTION

1.1 Purpose

The purpose of this design is to create an automatic transmission line sectionalizing scheme which is both cheap and reliable. It is also important that the scheme is flexible and easy to modify for transmission lines at various voltage levels.

1.2 Problem Statement

As energy prices increase and there is a push for a smarter energy grid, people are continually looking for ways to make the energy grid more reliable and efficient. Specifically, power outages can cause huge problems to any manufacturing company, effectively putting their business on hold. Also, many people's lives rely on getting power, whether the power is being used for something as simple as heat or whether it is powering life support equipment in a hospital.

Ideally, there would never be any outages on the power system. However, due to environmental issues, this is not possible. Power lines are subject to an array of weathering issues, whether it is lightning striking a line and knocking it down, or lines getting tangled in a tree while sagging under a high load. While some of these conditions are temporary and the faults created by them can be cleared through reclosers and circuit breakers with automatic reclosing, other conditions may be considered permanent, and require the utility or provider to send out crews to diagnose and fix the problem, which can take hours and hours of time.

This project aims to sectionalize transmission lines so the amount of customers that experience an extended outage is minimized.

1.3 Scope

The primary goal of this project is to demonstrate the ability to sectionalize transmission lines with the SEL 2411 PAC. Ideally, it would be nice to be able to see the PAC control actual MOABs, but due to the cost of MOABs this is not practical. However, the PAC is flexible enough to simulate a MOAB enough to show proof of concept, so this project focuses on getting this to work correctly.

2. BACKGROUND

This section will discuss the some of the background information in a scheme such as this and will also discuss some assumptions that will be made.

2.1 Background System and Assumptions

Most utilities have different standards as far as distribution goes, but most power companies have at least a few instances of the following configuration, seen in figure 1, somewhere on their systems.

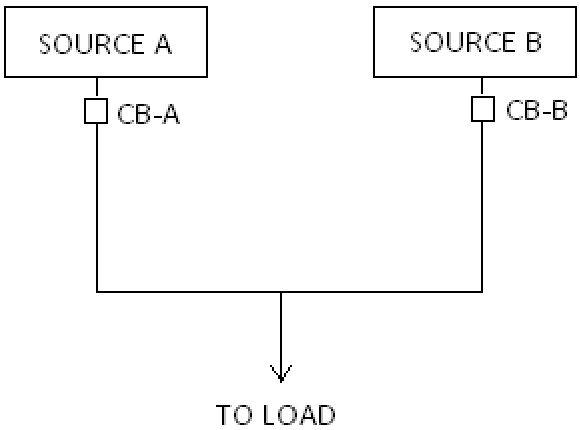

Figure 1 – Typical One-Line of a Distribution Configuration

As seen in this figure, there are two sources supplying some kind of load. It should be noted that these sources do not represent actual generators, but instead represent two separate paths for power to flow from generators at some other part of the system to the load. In our case, we will assume that past CB-A and CB-B, there is a single generator. This will prevent us from having to consider synchronization upon reclosing. Note that while this is an over-simplified case, the distribution system should be built in a way such that the voltage or current at these two points should not vary too much in magnitude or phase, and if it does, it can be assumed that other protective devices are taking care of this.

Different companies have different ways of handling their transmission line protection, so it is necessary to go through how the protection equipment operating CB-A and CB-B is functioning for different fault cases so that when MOABs are added, they will coordinate correctly.

The first fault consideration is a temporary fault anywhere on the line between CB-A, CB-B and the load. In this case, both circuit breakers will open to clear the fault within a few cycles, and then 10-15 cycles later both circuit breakers will reclose successfully.

The second fault consideration is a permanent fault between CB-A and the tap point. For a fault here, both CB-A and CB-B will go through a similar sequence as mentioned in the first case. However, upon a first and second fast reclose attempt, both will still see fault current. After these two fast reclose attempts, Circuit Breakers A and B will make a final reclosing attempt 30-60 seconds later and will lock out as they continue to see fault current. This delay between the 2nd and 3rd reclosing attempts will be exploited in the automatic line sectionalizing scheme and will be discussed later. However, without the line sectionalizing scheme, the last reclose attempt will be unsuccessful on both sides and the load will experience an extended outage.

The Third fault consideration is a permanent fault between CB-B and the tap point. Once again, CB-A and CB-B go through two unsuccessful fast-reclosing attempts. Like before, they will also have one final reclosing attempt 30-60 seconds later. Once again, this will be used in the line sectionalizing scheme. Just like scenario 2, without the line sectionalizing scheme, the last reclose attempt will be unsuccessful and the load will experience an extended outage.

There is one final fault configuration, but it can not be discussed until the positioning of the MOABs is discussed. However, the reclosing sequence for the breakers will be very similar with two unsuccessful recloses and then a final reclose attempt 30-60 seconds later for both CB-A and CB-B. These two reclose attempts will be unsuccessful without a line sectionalizing scheme.

3. REQUIREMENTS ANALYSIS

This section will discuss the overall project analysis and Implementation Considerations.

3.1 Principle of Operation

Two MOABs will be placed into the system depicted in figure 1 as seen in figure 2 below.

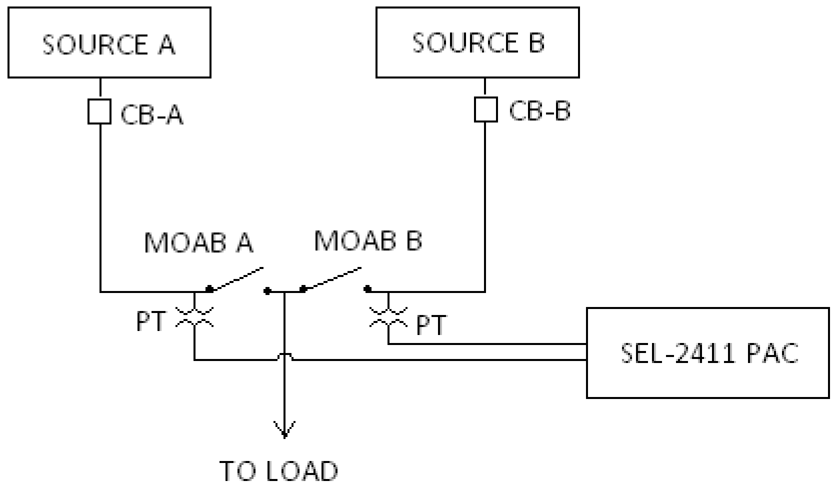

Figure 2 – Line sectionalizing Scheme Incorporated into a Distribution Configuration

As seen in figure 2, the MOAB's are directly next to the tap point, and there are two PT's on the source side of these switches sending a voltage measurement from one phase to the SEL-2411 PAC. These analog inputs will allow the SEL-2411 to decide whether the voltage the switch is seeing is considered "live" or "dead". The percentage of nominal voltage which separates the two is somewhat subjective and will be discussed later. Depending on whether or not the PT's are reading a voltage considered to be live or dead, the switches will operate accordingly. As any normal line sectionalizing approach aims to do, the purpose of these switches is to isolate the fault to a smaller section of the line and potentially prevent the load from experiencing an extended outage. For instance, if a fault can be isolated between CB-A and an open MOAB A, MOAB B can close in and restore power to the load. The specifics of the operation will be discussed in a later section.

3.2 Implementation Considerations

It should be noted that for the actual implementation of this scheme, the PT's and MOABs must be chosen in such a manner that the outputs of the PT's and MOABs do not exceed ratings for the SEL-2411 PAC. This will be briefly mentioned throughout the report, but because different companies use different standards, this report will not go into too much detail. These considerations are up to the power provider to decide, and different hardware cards can be chosen on the SEL-2411 for flexibility.

It should be noted that in most line sectionalizing schemes, there would be one controller for each MOAB, resulting in a higher cost. This scheme allows for a more affordable and smarter way to control the two MOABs to more effectively isolate faults.

Another important consideration involves the use of SCADA and other communication schemes in which the switches can be operated remotely through a master control station. This concept is built into the system design that is being proposed, but it is ultimately up to the power supplier whether or not this is desired. The benefits of such a system will be explored in a later section.

4. DESIGN WORK

This section will discuss the various methodology of the project design. In the Design Components section, all of the devices required for the project will be introduced and discussed. In the System/Logic Design section a detailed analysis of the logic and functionality will be discussed. In the Demo Design section, the changes needed in the logic for a demonstration are discussed. Finally, in the Template Design section, the various options for setting the SEL 2411 up are discussed.

4.1 Design Components

SEL-2411 Programmable Automation Controller

The SEL-2411 Programmable Automation Controller is the backbone of the proposed line sectionalizing system. A picture of it can be seen below in figure 3.

Figure 3 – SEL-2411 Programmable Automation Controller

This device will be where all the logic resides and where all the decision-making takes place. The 2411 has the following features to work with, although some features will not be included since they will not be used.

- Various Analog and Digital Inputs/Outputs
- Various communication ports, including Ethernet and Serial Ports
- 4 Programmable Pushbuttons, each with a programmable LED
- 6 Additional programmable LEDs.
- A programmable LED Screen
- Up to 32 Latches, Counters, and Math Variables
- Up to 64 Variables/Timers

These features provide an astounding amount of flexibility and allow the user to have many options. Since the Latches and Timers work just a bit differently that one may expect, it is worth talking a bit about each of them before continuing.

The Latches utilized by the 2411 have two inputs and one output. For the first latch, the designations are *SET01*, *RST01*, and *LT01*. If *SET01* is asserted, after one processing cycle *LT01* is asserted and stays asserted. If *LT01* is asserted and *RST01* is asserted, after one processing cycle *LT01* deasserts. It is important to mention that while using these latches, one must keep in mind that the *SET* input has priority over the *RST* input in the SEL-2411, so if the SET input remains high while the *RST* input is asserted, the output *LT01* will remain high. Therefore, when using these latches as memory elements, it is good practice to set or reset the latches using falling or rising edges instead of constantly setting or resetting the latch with a variable.

Another element which will be used in the design are Timers. Basically, each timer has three inputs. The first timer's inputs are designated *SV01*, *SV01PU*, and *SV01DO*. *SV01* if asserted will start the timer. After a number of seconds (set by input *SV01PU*) known as the pickup time, if *SV01* is still asserted, the output (*SV01T* for timer 1) will go high, signaling the input *SV01* has remained high throughout the pickup time. Finally, once this condition has been met, *SV01T* will go low as soon as the *SV01* input drops out for a period of time designated as *SV01DO*. Both the pickup and dropout times range from 0.000 to 16000.000 seconds. As an example say *SV01PU=1* and *SV01DO=10*. So, once whatever is driving the equation for *SV01* asserts it for at least one second, *SV01T* will go high and remain high as long as *SV01* is asserted. However, once *SV01* goes low, *SV01T* will go low after 10 seconds.

Most of the other logic elements, such as the ones that drive the LED's are self explanatory, so they will not be discussed in detail.

One of the advantages of using the SEL-2411 comes in the fact that a "template" can be created so that the logic equations driving the operations are somewhat transparent to the user. This allows the maker of the scheme to make it simple and flexible, with the user only having to set a few preferences and ignore all the logic equations. This advantage this presents will become more apparent throughout this report.

It should be noted that the software used in this application is called AcSELerator Designer. This program allows for the creation of templates, and also serves as a means of communicating between a user's PC and the SEL-2411. The template itself resides only on the user's PC, and the settings put into the template modify the equations that are sent into the SEL-2411. Unfortunately, when reading settings out of the SEL-2411, this means that the original template is not preserved, so the user must keep track of the template they loaded into the SEL-2411 to begin with.

Motor Operated Air Brake Switches

Because the main focus of this design is programming the SEL-2411, there are only a few relevant details of mention concerning the MOABs. First of all, in general, MOABs are NOT current interrupting devices! This is extremely important to mention, as opening a MOAB if current is flowing can produce an arc of current which can be damaging to both the equipment and to anyone that may be close to the MOAB when this occurs. This will be taken into consideration with the logic, and no manual or automatic operations will be allowed unless the line on which the switch resides is considered dead. The inability to interrupt current is what makes MOAB's much cheaper than breakers making them a much more attractive option to consider in line sectionalizing applications.

Secondly, once a MOAB is actually open, it will prevent current from flowing and serves as an open point in a system. The importance of this is that while the MOAB cannot interrupt fault current to isolate the fault, the MOAB can still isolate a fault after the fault is cleared by means of other protection such as circuit breakers or reclosers. To do this though, the switch must be coordinated to only open while the breakers clearing the fault are open. This will be discussed in the logic/system design section below in more detail.

One final detail worthy of mention is that there are two contact outputs that come out of each MOAB. One contact, the “a” contact, is asserted if the MOAB is fully closed. The other, the “b” contact is asserted of the MOAB is fully open. Basically, these two inputs should never be asserted at the same time for any length of time, or there is a problem with the MOAB. The SEL-2411 will use these contacts in its decision making.

Potential Transformers

Once again, because the main focus of this design is programming the SEL-2411, there are only a few important details that must be addressed. The PT used for this design is fairly flexible, and it is up to the user to pick what type of PT they would like to use. The SEL-2411 expects a 120 V input coming from the PT, so if the user wants to use this application on a 138 kV line they must step the 138 kV down to 120 V. This is accounted for in the aforementioned template when the user is originally setting up what will be sent into the SEL-2411. The template does a simple calculation that takes the user entered voltage of the line and the PT ratio to calculate how much voltage the 2411 itself will actually see.

4.2 System/Logic Design

The system design, which was shown previously in figure two, shows all the main connections except for outputs of the SEL-2411 going into the MOABs. The SEL-2411 will emit a one second pulse on either the open or close output which will control the MOABs. To lay the out the framework of the SEL-2411, the list in the attached Appendix A shows the assignments for all of the logic elements, latches, LED’s, inputs and outputs that will be used in this design. The labels for these assignments will become clear in time, but they may not be self-explanatory on first glance. It should be noted that these assignments are mostly arbitrary.

It now becomes important to go through the logic of this device. All of the logic settings can be seen in Appendix B, so this section will not contain actual equations. Instead, it will talk more about what the logic is actually set up to do and also will discuss certain considerations. It is difficult to pick a starting point for this discussion; all the logic is interweaved in the final product. Therefore, this section will be broken into multiple subsections. Something mentioned in the first section may not make sense until reading a later section, so it may be helpful to re-read sections or jump between sections to understand everything more clearly.

Pushbutton/Scada Functionality

There are four pushbuttons for local control of the MOABs. PB1 and PB2 enable or disabled automatic operations due to voltage sensing. PB3 resets the MOABs from auto-reclose lockout mode (which will be discussed later). Finally, PB4 enables or disables SUP control for SCADA use. The functionality for PB1-3 is available via SCADA if SUP control is enabled, along with the following: Open/Close MOAB A, Open/Close MOAB B. This SCADA control could be expanded, but for this application these commands are sufficient. It should be noted that if SCADA is used to open the MOABs, there is logic in place that prevents them from opening if voltage is present so that they do not interrupt current (as previously mentioned, they do not have the capacity to do so).

LED/Pushbutton LEDLogic

Most of the LED's in this system are quite simply driven by latches, which hold some kind of status indication such as whether MOAB A or B have automatic control enabled or not. This is true for every LED and pushbutton LED except the hotline indications for MOAB's A and B, which correspond with LED01 and LED02. One may also notice that the push button LED equations are OR'd with their respective pushbuttons. This allows the user to see whether or not the user is pressing hard enough for the SEL-2411 to recognize the push.

Status Logic

While this logic is not implemented in this scheme, it is important to mention. Status logic would be very similar to the aforementioned LED logic. However, this logic is used to interface with SCADA. A popular communication interface is DNP 3.0, in which certain status points (such as latch outputs) are assembled into a DNP "map". Each DNP status point is communicated to a master PC through some medium of communication so the remote user can see desired information before sending commands remotely. There is a setting in AcSELerator which requires one to use the SEL-2411 manual to create this map, in conjunction with the assignments found in appendix A. For instance, if the user wanted the first DNP point to indicate whether MOAB A is currently in automatic mode, the user must look up the DNP point corresponding to LT01 and enter that into the AcSELerator settings.

Automatic/Manual Open Logic

Before addressing this, is important to indicate what is considered automatic in this scheme. For this application, automatic refers to open or close commands that originate from decisions made by the SEL-2411 logic due to the input voltages seen by the SEL-2411. This is different from a manual open or close because the manual open or close originates from SCADA through remote bits.

It is important now to discuss what automatically opening the switches in this scheme does. It was mentioned before that the third circuit breaker reclosing attempt for a permanent fault occurs 30-60 seconds after the fault starts. During this time, the PT's connected on the source side of the switches should see a dead line, and after a user designated time, both switches should open. This opening "sectionalizes" the line, isolating the fault. For the case where the fault was between CB-A and MOAB A, the fault will now be contained between these two points instead of extending to the rest of the system. While the 3rd reclosing attempt on the A side will be unsuccessful, the delayed 3rd reclosing attempt on the B side will be a success because the fault is now isolated. Although this will be discussed in a later section, the MOAB switch will close automatically after CB-B successfully recloses, which will successfully re-energize the load. This works for a fault between CB-B and MOAB B as well, with the A side picking up the load. In the case in which the fault occurs between the two MOABs on the load side, both of the 3rd circuit breaker reclosing attempts will be successful. However, this case is a bit more complicated, as automatic reclosing of the MOABs result in closing into the permanent fault again. This will be discussed in the lockout section.

As seen in the logic, OUT301 and OUT303 are designated as the outputs that send commands to the MOABs. Each of these are driven by two timers, one which comes from a Supervisory (manual) open command, and the other which comes from automatic control. The Supervisory timers are asserted if and only if both PTs see a dead voltage (remember, MOABs can't interrupt current so both lines must be dead! SV04T being asserted denotes this), SUP control is enabled, (LT04), and a SUP command has been sent through RB01 or RB03. In the case of MOAB A, this results in SV09T going high for one second, which in turn means OUT301 goes high and opens the MOAB

For the Auto Open timer to go high, both lines must once again be dead, the MOAB "a" contact must be asserted (IN301), Auto Open Block must not be asserted (NOT SV19T), and Auto Reclosing must be enabled for that MOAB (LT01 for MOAB A). If all of these conditions are met for a user-designated amount of time (as set in the template) the SEL-2411 will send a open command to the MOAB.

The automatic open block logic basically prevents each MOAB for opening for a user designated time after a successful closing. Sometimes right after a closing, the voltage may temporarily sag for a few seconds while load is picked up. This effect is mostly transient but this setting allows the user to ride through such instances.

Automatic/Manual Close Logic

As mentioned before, an automatic close is desired once potential returns to a MOAB for a certain amount of time. The time in which the automatic close takes place should be staggered between MOAB A and MOAB B so that in the case that a permanent fault resides between the two MOAB's, only one MOAB closes into it before locking out and opening back up. With some additional lockout logic, this prevents one of the MOABs from closing into a fault.

The Automatic close logic is somewhat similar to the auto open logic. Once again, in the case of MOAB A, auto operation must be enabled (LT01), the MOAB must be open (NOT IN301), Auto Close Block must stay low (LT07), the PT output must be higher than the dead line voltage for a settable time(SV13T), and Auto-Reclose Lockout must not be in effect (NOT LT05). The auto close block prevents a closing directly after an opening for a certain amount of time. Once again, if all these conditions are met, a 1 second close pulse is sent through OUT302 to MOAB A (or OUT304 to MOAB B). A supervisory-controlled close command will be sent if SUP is enabled (LT04) and SCADA asserts RB02.

Auto-Reclose Lockout Logic

There are three main conditions which would require the MOABs to go into an Auto-Reclose lockout state, preventing any reclosing from occurring. The first condition occurs when one of the MOABs closes and immediately loses voltage due to closing into a fault (which is quickly cleared by the circuit breakers). The logic for this is interposed with the auto-close block logic, as the two are somewhat related. It should be noted that although the switch goes to auto-reclose lockout in this case, it does NOT open back up until both MOABs experience a loss of voltage for a user-programmed amount of time. This time can be set in the template.

The second case in which a MOAB may go into lockout is somewhat similar to the first case. If there is a fault between the MOABs, both CBs will go through two unsuccessful reclosing attempts. After these attempts, both MOABs should automatically open after experiencing a loss of voltage for 0-30 seconds (depending on the user's setting). After this, both CB's have one final reclosing attempt, which is successful. Once voltage returns to the MOABs, they are programmed to automatically close in after a settable delay. However, recall that both MOABs would be closing into a fault, and this requires both CB's to go through a trip/reclosing sequence. Therefore, to prevent this from occurring, there is logic in place that if MOAB A goes into lockout due to losing voltage when closing, MOAB B is automatically sent to lockout too preventing it from closing into a fault. This is an additional benefit of having the control for both MOABs in one box.

The final case in which a MOAB should be put into lockout mode would be if both the "a" closed contact and "b" open contact from one of the MOABs are asserted at the same time (called an incomplete sequence). This would indicate that something is wrong with the MOAB and it is not opening or closing correctly. Putting it in lockout will prevent any further faulty operations. LT09 and LT10 are used to signal whether or not this incomplete sequence condition is occurring. It should be noted that there is a LED driven by each of these latches which lights up when there is a problem.

It should be noted that once either of the MOABs are in lockout, there is a LED which lights up to denote this on the third pushbutton. To remove the lockout condition from either or both of the MOABs, one must push PB3. Another option is to pulse RB09 from SCADA while SUP control is enabled. Both of these actions reset LT09 and LT10, resulting in auto reclosing to be enabled once again.

4.3 Demo Design

As previously mentioned, it is not feasible to demo this project with actual MOABs so the logic in the SEL-2411 had to be modified to account for this. Instead of using actual MOABs, the SEL-2411 simulates these MOABs with latches. These latches are set or reset by the same outputs that would open or close the MOABs. Also, instead of LED5 and LED6 showing incomplete sequence indications, they are driven by the aforementioned latches to show if each MOAB would either be closed or open. Also, instead of actual voltages being fed into the inputs of the SEL-2411 for live line indication, Remote Bits can be used to simulate these voltages being on. This allows for safe demonstration and proof of concept.

4.4 Template Design

The PC interface for the Template which will generate the settings for the SEL-2411 can be seen below, in figure 4.

Figure 4 – Template Configuration

As seen in this figure, there are various settings which can be set, such as primary voltage, PT ratio, and various automatic operation settings. This template allows the user to easily modify a few simple settings to suit the scheme to their own transmission line, without having to worry about making the changes to the logic itself. This is a huge advantage for the customer, and adds a ton of flexibility to the system.

4. Resources/Misc.

The following resources were used in the creation of this project.

- A Personal Computer
- AcSELerator Designer Software
- SEL-2411 Programmable Automation Controller

Andrew Dulmage is a senior at The Ohio State University, majoring in Electrical Engineering. He has taken all his core classes, and has taken various courses in both power and computer specializations. Outside of classes, he has worked with three different companies: Liebert Corporation, FirstEnergy, and Schweitzer Engineering Laboratories. At Liebert, he worked in the research and development department, concerning a new design of an uninterruptable power source. At FirstEnergy, he worked in the Energy Delivery Planning and Protection department, analyzing and locating faults on the power lines. He also worked extensively with Digital Fault Recorders and Relay devices, specifically concerning the settings of these devices. Finally, at Schweitzer Engineering Laboratories, Andrew has worked on Distribution Automation using SEL 651-R recloser controllers and the SEL-3351 computing platform.

Special thanks go to Professor Kasten of the Ohio State University for helping and bringing up certain issues which needed to be taken into consideration. Also, Jim Schnegg of Schweitzer Engineering Laboratories assisted in troubleshooting some of the logic and making various suggestions. Finally, thanks to Schweitzer Engineering Laboratories for donating a SEL-2411 for testing use.

Appendix A - Assignments

Pushbutton Assignments
PB01 – Auto on/off MOAB A
PB02 – Auto on/off MOAB B
PB03 – Lockout Reset (LED on when in LO)
PB04 – Sup Control – Local/Remote – PB LED on when in Remote

LED Assignments
LED1 – A PH hot
LED2 – C PH hot
LED3 – MOAB A in LO
LED4 – MOAB B in LO
LED5 – Incomp. Seq MOAB A
LED6 – Incomp. Seq MOAB B

Input Assignments
MOAB A "a" contact – IN301
MOAB A "b" contact – IN302
MOAB B "a" contact – IN303
MOAB B "b" contact – IN304

Output Assignments
OUT301 – Open MOAB A
OUT302 – Close MOAB A
OUT303 – Open MOAB B
OUT304 – Close MOAB B

Remote Bit Assignments (Commands from Scada)

RB01 – Open MOAB A
RB02 – Close MOAB A
RB03 – Open MOAB B
RB04 – Close MOAB B
RB05 – MOAB A Auto Enable
RB06 – MOAB A Auto Disable
RB07 – MOAB B Auto Enable
RB08 – MOAB B Auto Disable
RB09 – Lockout Reset

Latch Assignments
LT01 - Auto on/off MOAB A
LT02 - Auto on/off MOAB B
LT03 – NA
LT04 – Sup Control – Local/Remote – Set on when in Remote
LT05 – Auto Reclose Lockout A
LT06 – Auto Reclose Lockout B
LT07 – Auto Close Block A
LT08 – Auto Close Block B
LT09 – MOAB A Incomplete Sequence
LT10 – MOAB B Incomplete Sequence
Timer Assignments
SV01 – Used for A PH hot
SV02 – Used for C PH hot
SV03 – Indicator for B Hot, A Closed
SV04 – Auto Open MOAB Timer (Both Lines Dead)
SV05 – Used for Auto Close Blocked MOAB A
SV06 – Used for Auto Close Blocked MOAB B
SV07 – MOS Lockout A
SV08 – MOS Lockout B
SV09 – Sup Open MOAB A
SV10 – Sup Open MOAB B
SV11 – Auto Open A
SV12 – Auto Open B
SV13 – Auto Close A hot timer
SV14 – Auto Close B hot timer
SV15 – Auto Close A
SV16 – Auto Close B
SV17 – Sup Close MOAB A
SV18 – Sup Close MOAB B
SV19 – Auto Open Block A
SV20 – Auto Open Block B
SV21 – Used in Lockout of B after closing A

Math Variable Assignments
MV01 – Hot line Setting